DISTRIBUTION OF NON-ODORIZED GAS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application No. 60/396,205 filed July 15, 2002, where this provisional application is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to systems and methods for distributing a non-odorized gas.

Description of the Related Art

As a clean and efficient manner of generating electricity, electrochemical fuel cells have been the focus of considerable attention over the last decade. However, one challenge to the commercialization of electrochemical fuel cells has been and continues to be the development of an efficient and economical means for supplying the necessary fuel. In particular, with respect to the use of hydrogen-based fuel cells, a method for supplying hydrogen to a geographically widespread area is needed. Many proposals have focused on a decentralized distribution system in which hydrogen is produced locally at numerous refueling points, either through the utilization of hydrocarbon fuels and fuel reforming technologies or through the electrolysis of water.

Existing distribution systems employ a network of pipelines for delivering fuel, such as natural gas, propane or liquefied petroleum gas (LPG). Odorants are commonly added to the fuel to assist in detection of leaks in the distribution pipelines or at the point of consumption. The most common forms of such odorants are

mercaptans and thiophenes, sulfur compounds that impart an unpleasant and strong odor to the fuel. Unfortunately, sulfur compounds can poison fuel cell catalysts.

To date, a comprehensive plan for developing a hydrogen distribution infrastructure has not been determined. Accordingly, there remains a need in the art for an efficient and economical method for supplying hydrogen to a geographically widespread area without the need for adding odorants to the hydrogen. The present systems and methods fulfill these needs and provide further related advantages.

BRIEF SUMMARY OF THE INVENTION

The present invention is generally directed to systems and methods for distributing a non-odorized gas.

In one embodiment, the present system for distributing a non-odorized gas comprises an inner pipe adapted to contain the non-odorized gas at a first pressure, and an outer pipe adapted to contain an odorized fluid at a second pressure where the inner pipe is routed through the outer pipe and the first pressure is greater than the second pressure.

As a result of the pressure differential, a leak in the inner pipe will not permit the odorized fluid in the outer pipe to flow into the inner pipe. When the non-odorized gas is hydrogen, this prevents a stream of hydrogen gas that is possibly contaminated with odorants from reaching the systems of consumers, such as fuel cell systems. Furthermore, a leak in the outer pipe will result in the release of the odorized fluid into the environment and a leak in both the inner and outer pipes will result in the release of both the non-odorized and odorized fluids into the environment. In both situations, the release of an odorized fluid into the environment allows the leak to be detected before the leak reaches dangerous or harmful levels.

In one embodiment, the present method for distributing a non-odorized gas comprises supplying the non-odorized gas at a first pressure in an inner pipe, supplying an odorized fluid at a second pressure in an outer pipe; and routing the

inner pipe through the outer pipe, where the first pressure is greater than the second pressure.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE FIGURES

In the figures, identical reference numbers identify similar elements or acts. The sizes and relative positions of elements in the figures are not necessarily drawn to scale. For example, the shapes of various elements and angles are not drawn to scale, and some of these elements are arbitrarily enlarged and positioned to improve figure legibility. Further, the particular shapes of the elements, as drawn, are not intended to convey any information regarding the actual shape of the particular elements, and have been solely selected for ease of recognition in the figures.

FIG. 1 is a schematic drawing of a portion of an embodiment of the present distribution systems and methods.

FIG. 2 is a cross-sectional side view schematically illustrating a junction box according to another embodiment of the present distribution systems and methods.

FIG. 3 is a cross-sectional side view schematically illustrating a junction box according to a further embodiment of the present distribution systems and methods.

FIG. 4 is a cross-sectional side view schematically illustrating a junction box according to a still further embodiment of the present distribution systems and methods.

FIG. 5 is a cross-sectional side view schematically illustrating a source of non-odorized gas employing an embodiment of the present distribution systems and methods.

DETAILED DESCRIPTION OF THE INVENTION

The present detailed description is generally directed toward systems and methods for distributing a non-odorized gas. In the following description, certain

specific details are set forth in order to provide a thorough understanding of various embodiments of the present systems and methods. However, persons skilled in the art will understand that the present systems and methods may be practiced without these details. In other instances, well known structures associated with distribution systems, such as valves and sensors, have not been described in detail to avoid unnecessarily obscuring the descriptions of the embodiments of the present systems and methods.

Unless the context requires otherwise, throughout the specification and claims which follow, the word "comprise" and variations thereof, such as "comprises" and "comprising" are to be construed in an open, inclusive sense, that is as "including but not limited to."

FIG. 1 illustrates a portion of an embodiment of the present distribution systems and methods. As shown, an inner pipe 104 is routed through an outer pipe 102. Inner pipe 104 is adapted to contain a non-odorized gas, such as hydrogen, at a first pressure. Outer pipe 102 is adapted to contain an odorized fluid, such as natural gas, propane or LPG, at a second pressure. In FIG. 1, inner pipe 104 and outer pipe 102 have circular cross-sections, however, the cross-sectional shape of the pipes is not essential to the present systems and methods. Similarly, the pipe material is not essential to the present systems and methods, and persons of ordinary skill in the art can readily choose inner and outer pipes suitable for a given application. Finally, if desired, inner pipe 104 may be supported within outer pipe 102, as will be apparent to persons of ordinary skill in the art.

In the illustrated embodiment, the pressure of the non-odorized gas in inner pipe 104 is greater than the pressure of the odorized fluid in outer pipe 102. In this way, a leak in inner pipe 104 will not permit the odorized fluid in outer pipe 102 to flow into inner pipe 104 and contaminate the non-odorized gas. (Where the non-odorized gas is hydrogen and the odorized fluid is a hydrocarbon, leaking of hydrogen into the outer pipe poses no problems. However, for economy of hydrogen, the odorized fluid may be sampled to detect leaks of the non-odorized gas into the

odorized fluid.) Furthermore, a leak in outer pipe 102 will result in the release of the odorized fluid into the environment and a leak in both inner 104 and outer 102 pipes will result in the release of both the non-odorized and odorized fluids into the environment. In either situation, a release of an odorized fluid into the environment occurs and may be detected by users before the level of non-odorized gas in the surrounding environment reaches dangerous or harmful levels (such as, for example, where the non-odorized gas is flammable or poisonous). As further shown in FIG. 1, inner pipe 104 is connected to an inlet pipe 106 at an inlet point 124. Inlet pipe 106 may be connected to inner pipe 104 by a number of means, including welding. Inlet pipe 106 is adapted to contain a non-odorized gas, such as hydrogen, and allows the introduction of a non-odorized gas from a source 112 into a distribution system for an odorized fluid carried in outer pipe 102. Where the non-odorized gas is hydrogen, for example, source 112 could comprise a hydrogen storage or production facility such as a pressurized hydrogen tank, an electrolyzer or a hydrocarbon fuel processing system.

Inlet pipe 106 is contained within a containment unit 108 so that a leak in inlet pipe 106 will not result in the release of the non-odorized gas into the environment. Furthermore, as illustrated, the containment unit 108 also contains a sensor 110 adapted to detect the non-odorized gas. Upon detection of a leak, sensor 110 can alert users to the presence of such a leak. Sensor 110 may provide such notification by a number of means, including transmitting a signal to a remote location or activating an alarm that is audible within the vicinity of the containment unit 108. The selection of a particular sensor is not essential to the present systems and methods and a person of ordinary skill in the art can select a suitable sensor for a given application. In another embodiment, sensor 110 may be adapted to trigger a means for reducing the concentration of the non-odorized gas in containment unit 108, such as a blower.

As also shown in FIG. 1, inner pipe 104 is connected to an outlet pipe 114 at an outlet point 126. Outlet pipe 114 is adapted to supply the non-odorized gas

to a user 122. Users of the non-odorized gas may include consumers, re-fueling stations, factories and other commercial businesses. Outlet pipe 114 is contained within a containment unit 116, having sensor 118. Containment unit 116 and sensor 118 are substantially the same as containment unit 108 and sensor 110 described above. In an alternative embodiment (not shown), the system (for example, outlet pipe 114) may be adapted to supply the odorized fluid to the user 122, in addition to the non-odorized gas, to be used for heating, etc.

A control valve 120 is connected to outlet pipe 114 and is adapted to prevent the flow of the non-odorized gas through outlet pipe 114. For example, if the pressure of the non-odorized gas in inner pipe 104 drops below the pressure of the odorized fluid in outer pipe 102, control valve 120 can be closed. This may prevent the flow of a possibly contaminated non-odorized gas to a user. In another embodiment (not shown), purging/reset apparatus may be incorporated into the system such that any non-odorized gas contaminated by odorized gas prior to the closing of control valve 120 can be removed from the non-odorized gas distribution system.

FIG. 2 illustrates a junction box according to one embodiment of the present systems and methods. In junction box 138, a length of outer pipe 102 is connected to valve 130, which regulates the flow of the odorized fluid through outer pipe 102. A portion 132 of inner pipe 104 is routed outside of outer pipe 102 contained in junction box 138, bypassing valve 130. Valve 134 and valve 136 are connected to outer pipe 102 and allow the odorized fluid to be released from outer pipe 102 into junction box 138. Junction box 138 is adapted to contain the odorized fluid at a pressure lower than the pressure of the non-odorized gas in inner pipe 104. In this way, a leak in re-routed portion 132 of inner pipe 104 will not result in the release of non-odorized gas into the environment or introduction of odorized fluid into inner pipe 104. Furthermore, a leak in junction box 138 or a leak in both re-routed portion 132 of inner pipe 104 and junction box 138 will result in the release of odorized fluid into the environment which may be detected by users before the leak reaches

dangerous or harmful levels. In a further embodiment, valve 130 is magnetically coupled to allow it to be controlled from outside of junction box 138.

FIG. 3 illustrates a junction box according to another embodiment of the present systems and methods. In junction box 148, inner pipe 104 is connected to valve 140 that regulates the flow of the non-odorized gas through inner pipe 104. A portion 142 of inner pipe 104 is routed outside of outer pipe 102 to allow access to valve 140. Valve 144 is connected to outer pipe 102 and allows odorized fluid to be released from outer pipe 102 into junction box 148. In other material respects, junction box 148 functions substantially the same as junction box 138 described above. As with valve 130 described above, valve 140 may be magnetically coupled to allow it to be controlled from outside of junction box 148.

FIG. 4 illustrates a junction box according to yet another embodiment of the present systems and methods. In junction box 158, inner pipe 104 is connected to valve 150 that regulates the flow of the non-odorized gas through inner pipe 104. A portion 152 of inner pipe 104 is routed outside of outer pipe 102 to allow access to valve 150. Also in junction box 158, a length of outer pipe 102 is connected to valve 156, which regulates the flow of the odorized fluid through outer pipe 102. Valves 154 are connected to outer pipe 102 and allow odorized fluid to be released from outer pipe 102 into junction box 158. Valve 150 comprises a double gland seal, comprising inner gland 150a and outer gland 150b. Valve 156 comprises a single gland seal. A leak in inner gland 150a will not result in the release of non-odorized gas into the environment, while a leak in outer gland 150b or valve 156 will result in the release of odorized fluid into the environment. In other material respects, junction box 158 functions substantially the same as junction box 138 described above. In still another embodiment of the present systems and methods, valves 150 and 156 may be incorporated into a single valve assembly on one shaft, so that the flow of odorized and non-odorized fluids may be shut off simultaneously.

FIG. 5 illustrates an example of a source 112, employing one embodiment of the present systems and methods. Source 112 comprises an

underground storage container 160, such as a pressurized hydrogen tank, for storing non-odorized gas, which feeds inlet pipe 106. Storage container 160 and the underground portion of inlet pipe 106 are contained within an enclosure piping 162. Inlet pipe 106 and enclosure piping 162 lead to an above-ground junction box 168, with enclosure piping 162 being open to junction box 168.

Non-odorized gas may be supplied to storage container 160 and inlet pipe 106 via a valve 170, also contained in junction box 168. Valve 166 controls the flow of non-odorized gas in inlet pipe 106 out of junction box 168 through containment unit 108 and to the balance of the distribution system. Odorized fluid is supplied to junction box 168 and enclosure piping 162 via a valve 172 until a desired pressure of odorized gas in junction box 168 and enclosure piping 162, less than the pressure of the non-odorized gas in storage container 160 and inlet pipe 106, is reached. As shown in FIG. 5, a pressure relief valve 164 may be connected to enclosure piping 162. Although not shown, in alternative embodiments pressure relief valve 164 may vent dye for a visual signal of a leak, or may comprise a burst disk.

Accordingly, a leak in storage container 160 and/or inlet pipe 106 will not result in the release of the non-odorized gas into the environment. If there is a leak of non-odorized gas, the pressure inside junction box 168 and/or enclosure piping 162 will increase, triggering pressure relief valve 164, releasing odorized fluid to the environment, enabling a leak of the non-odorized gas to be detected. In addition, the likelihood of unintentional damage to storage container 160 or the underground portion of inlet pipe 106, by, for example, a backhoe operator, may be reduced, since enclosure piping 162 will be damaged and odorized fluid released to the environment before storage container 160 or inlet pipe 106 is reached.

In an alternative embodiment, junction box 168 may be configured to supply the non-odorized gas directly to a non-odorized gas user. For example, if source 112 is configured to supply only a single user, such as a fuel cell, containment unit 108 may be unnecessary. Potential leaks in inlet pipe 106 outside of junction box 168 may be addressed via a sensor, or alternatively, without a sensor by, for example,

restricting the flow in inlet pipe 106 outside of junction box 168 to a small amount and using passive or active ventilation at a rate greater than the restricted flow rate in inlet pipe 106.

The present systems and methods provide for a simple and efficient distribution of non-odorized gases such as hydrogen. In particular, the present systems and methods can be adapted to current distribution systems for fuel gases such as natural gas, propane, LPG, etc.

From the foregoing it will be appreciated that all the specific embodiments of the invention have been described herein for purposes of illustration, and various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.